Article

Evaluating land use and land cover change of Tinishu Abaya wetland found in Silite Zone, SNNPRS, Ethiopia

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Abstract
Wetlands are among most important multi-functional and productive ecosystems on the earth but seriously threatened landscape by adverse human utilization practices and environmental changes like degradation. Thus, this study was conducted to determine the degradation level of Tinishu Abaya wetland in Silte zone, southern Ethiopia. The magnitude of land use and land cover (LULC) change was detected using Landsat images obtained in 1988, 2004, and 2018. LULC change and was analyzed using ArcGIS of version 10.4. The findings from satellite imagery analysis revealed the prevalence of wetland degradation within the study area. The result from LULC change between 1988 and 2018 confirmed severe degradation of wetland mostly due to the expansion of farmland. The highest incremental change was observed in farmland, while the highest decrement was seen in the grassland that reached nearly 50% of LULC in 1988. On the other hand, wetland and the lake showed a declining trend up to 40% and 25%, respectively, while settlement showed an incremental trend reaching up to 46%. Even if the LULC change occurred between 1988 and 2018 years, remarkable changes were observed during 2004-2018 (14 years). Therefore, developing alternative methods of wetland resources, creating awareness about the indirect benefits of wetlands, monitoring of upstream-downstream user relations, and developing an appropriate wetland management interventional policy are recommended

Keywords degradation; land use and land cover change; remote sensing; satellite.

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1 Introduction

Land is vital natural resource with numerous economic, social, and ecological purposes in which LULC dynamics occur due to societal growth and environmental influences (Zhang et al., 2006; Hailu et al., 2020). Wetlands are among these land parts and the most important multi-functional and productive ecosystems on the earth (Mengesha, 2017; Davidson et al., 2019) but threatened by man (Mintesnot et al., 2021) and environmental degradation and climate change impacts (Zhang and Liu, 2012; Mariye et al., 2022)

Ethiopia owns more than 58 different types of wetlands (Eisenhauser et al., 2011) and all sizes play a vital role in supporting the livelihoods of people throughout Ethiopia as a basic safety net of food and water security for many of the poorest people (EPA, 2003) while, for others they offer an opportunity to develop and diversify livelihood and income generating (Dixon et al., 2021). Despite recognizing their many uses by people, their ecological services to humankind, and environmental significance, Ethiopian wetlands are under severe pressure and degradation (Bezabih et al., 2017) due to wetlands and their value little understood (Gebresllassie et al., 2014). Land Use and Land Cover (LULC) changes greatly influence catchment hydrologic processes such as surface runoff and stream flows (Rientjes, et al., 2011; Koch et al., 2012, Gyamfi et al., 2016) has significant impacts on the productivity of rangelands (Mussa et al., 2016), and has impacted the climate and weather conditions from local to global scales (Kayet et al., 2016; Pielk et al., 2006). The LULC changes become aggregated to widespread, and the changes significantly affect the major aspects of Earth's systems and processes. Therefore, LULC change studies become imperative to provide sustainable land resource use, rehabilitation measures, and evidence-based support to improve management (Kuma et al., 2022).

LULC change analysis is one of the most useful methodologies to understand how the land was used in the past years, what types of detections are to be expected in the future, as well as the driving forces and processes behind these changes (Regasa et al., 2021). Currently, studies were conducted on land cover change in Ethiopia were executed by using remotely sensed images (Kuma et al., 2022) and provides an important source of information to be utilized for land conservation, sustainable development, and management of water resources (Dires et al., 2020). It has been broadly engaged for LULC change detection from small to large (Fichera et al., 2012).

In Ethiopia, studies made by different scholars using remote sensing, indicated a decrease in forest covers, and an increase of cultivation lands were reported between 1973 and 2008 in Batena Watershed, Southern Ethiopia (Gebiaw et al., 2016) and increased farm and built-up areas from 1984 to 2015 while, a decline of forest and water bodies from 1984 to 1999, and once more the forest and water bodies increased from 1999 to 2015 in Beressa, Northern Ethiopia (Meshesha et al., 2016). Furthermore, numerous studies in Ethiopia reported LULC changes resulted in a significant increase in cultivation lands (Elias et al., 2019; Degife et al., 2021; Kuma et al., 2022].

As this study was conducted in Tinishu Abaya wetland found in Rift Valley Basin, it shares characteristics exhibited like high competition for irrigation water, decline of natural woodlands, overgrazing, and cultivation of steep slopes experiencing several featured practices and distinguished by rivers, lakes and terrestrial ecosystems that resulted in remarkable LULC change trends that showed a decline in woodlands, soil erosion, settlement and overpopulation, sedimentation, drying of small lakes (Gebiaw et al., 2016; Elias et al., 2019; Degife et al., 2021).

In the study area, Tinishu Abaya wetland degraded progressively due to different natural (drought, siltation and flooding and soil erosion) and human factors (SZAND, 2020). The accelerated deterioration of the wetland resources and their functions, therefore, calls for critical measures, which can create agreement among wetlands users and ecological functions and values of wetlands. Understanding the scope of land use change is very crucial for proper management of land resources (Belayneh and Eyasu, 2021). There was a limitation of study that highlights the trend and magnitude of the Tinishu Abaya wetland degradation. Hence this study was designed to address the following objective:

i) To assess land use and land cover change of Tinishu Abaya wetland found in Silte zone.
ii) To determine the degradation level of Tinishu Abaya wetland.

2 Materials and Methods

2.1 Study site

Tinishu Abaya wetland stretches between Silti and Lanfuro districts in the Siltie Zone. It covers a total area of 10005.03 ha, located in the Ethiopian Rift Valley, nearly 160 km southwest of Addis Ababa at 70 0'0" N to 7029´03.65´´N latitude and 38003`17.79´´E to 380 31'12"E Longitude, and its altitude ranges from 1870-2000 m a.s.l. and the wetland is situated nearly 15 km away from main road that crosses Silti district by passes from Addis Ababa to Hadiya zone. Based on the 2007 population and house census report, the total populations of the 1st study area were reported to be 305982, of which 49.68% were males while the remaining 50.32% were females. The total population of the study area in 2018 was 40520. Hence, the population density of the study area is 405 persons per km^2.

2.2 Climatic condition and land use practice at study area

The agro-ecology of the study area is dominated by dry Weyna Dega (midland) and characterized by frequent drought, and hence moisture stress is the central problem for agricultural production. It has a uni-modal rainfall distribution in winter, of which a maximum average annual rainfall is estimated at less than 900 mm. The small rainy season occurs from March to April, maximum from June to September, the maximum annual range of temperature recorded in the winter season (30^oC), and the minimum annual temperature recorded during the summer season (18^oC) (DANO, 2020). The study area has different land uses such as cultivated land, settlement, water body, and grazing lands, and the study area is dominated by litosol and the textural class is dominated by sandy (DANO, 2020). The farming systems in the district are characterized by mixed farming. The agro-climatic condition of the district is favorable for growing diversified types of crops and rearing of animals.

2.3 Research methodology

2.3.1 Research design

The study was conducted based on desk study/data collection of RS and GIS data and observations (Zeisel, 1980). The collected data were classified as RS data from 1988, 2004, and 2018 delineated to study area and land use and land cover of all data from three periods were quantified using ArcGIS version 10.4 (Table 1). This study adopted the use of survey design in a natural research setting. A range of data collection techniques were employed to check the quality of data.

2.3.2 Data collection

Primary and secondary data were used for this study. Ground control points (GCP) for ground truth were collected as primary data using handheld GPS. The primary data source was collected by remote sensing (Landsat image) and field observation; whereas the secondary data was collected from Silti district office and journals published and unpublished reports.

To analyze the change of the lake and its surroundings in the study area, Landsat imagery of 1988 (TM), 2004 (ETM), and 2018 (ETM+) was freely downloaded from United States Geological Survey (USGS) Google Earth Explorer website. A total of 30-year gap Landsat imagery was used due to most of the elders in the study area reporting that this lake was declined between these 30 years (Table 2).

Landsat based classification is preferred due to it considered providing the greatest spectral reflectance resolution (Mengistie et al., 2013; Gerubin, 2017). The land use and land cover status were identified through the classification of Landsat imagery acquired in January 1988, 2004 and 2018 in ArcGIS version 10.4. Landsat images acquired on January, 1988 were selected as the historical image and used for change detection on 2004 and 2018 images. These satellite images were acquired in January to get clearer sky free of cloud to reduce the radiometric distortion on the image quality, which may hamper the image interpretation process.

Table 1 Materials and software used in the current study.

Type	Description	Source
Map	Country, Region, Districts kebele shape files	EMA
Soft wares	ArcGIS 10.4,WinRAR	Download from internet
Instruments	Digital camera and GPS	Woreda office

Table 2 Summary of satellite images used in land use and land cover change detection.

No. of Satellite	Image Types	Path/Row	Acquisition Date	Spatial Resolution (m)	Source
1	Landsat TM	168/055	January 01/1988	30*30	USGS
2	Landsat ETM	168/055	January 12/2004	30*30	USGS
3	Landsat ETM+	168/055	January 15/2018	30*30	USGS

2.3.3 Data analysis

(1) Satellite image processing

Preprocessing involves those operations that are normally required prior to the main data analysis and extraction of information. The downloaded satellite images were in tiff format having different layers and were stacked in ArcGIS version 10.4 software to produce one single layer image composed of each band. The raw data were geo-referenced by ArcGIS software version 10.4 and extracted from the boundary of the study area for further processing. To improve the visual interpretation; image enhancement is done for increasing the apparent distinction between features in the scene. For image enhancement, contrast manipulation was used

(2) Image classification

Based on the land sat-image reflectance, the shape files of training points, and the information gathered by field observation, supervised classification were done. For this study, five major LULC classes such as wetland, Lake, grassland, farmland, and settlement were identified for mapping (Table 3). Identification of some of the LULC classes was carried out by field visiting (for Landsat 2018) and found what types of changes were appearing over time. Categorizations of LULC types were concluded with the production of the LULC legend, establishment of its characteristics, and identification and mapping of LULC types.

(3) Accuracy assessment

To assure wise use of land cover maps and accompanying statistics derived from RS analysis, the errors must be quantitatively explained (Marambanyika et al., 2021). It involves the production of references (samples) that evaluate the produced classification. These references were produced from Google Earth and GPS points during fieldwork, which were independent of the ground truths used in the classification. In this study, reference test samples were randomly selected from Google Earth for images between 1988 and 2004; whereas, GPS data were collected from the ground for image 2018.

Table 3 Description of land use/land cover categories or classes for which changes were detected for the period between 1988 and 2018.

LULC change class	General Description
Lake	Indicates the water body surrounded by land mass; particularly Tinishu Abaya.
Farm land	Areas selected to crop production, mostly of cereals in Subsistence farming.
Settlement	Areas composed of small villages and/or scattered hamlets.
Wetland	Moist area which is found near to the lake and dry land
Grassland	Lands predominantly covered with grasses, fobs, and grass areas used for communal grazing.

(4) Rate of LULCC

The land cover map image of the three periods was analyzed based on LULC type. Accordingly, the area comparison of land use and land cover changes for 30 years and the rate of change for each land use and land cover type was calculated for the three periods from 1988 to 2004, 2004 to 2018 and 1988 to 2018, and computed using the formula of Amanuel (2011):

$$r = (Ar - Ap)/t \qquad (1)$$

where, r = Rate of change in ha/year, Ar = Recent area of the LULC in ha, Ap= Previous area of the LULC in ha, t = Time interval between Ar and Ap in years.

3 Results and Discussion

Land use and land cover changes (LULCC) are important elements of the global environmental change processes (Leykun, 2003). The selection of the image data was based on study area coverage and cloud cover less than 10%. Accordingly, five major land classes, namely, wetland, farmland, lake, settlement, and grass land, were identified in the study area (Fig. 1). The study result of the image taken in 1988-2018 revealed that there is continuing degradation of Tinisu Abaya wetland.

3.1 Trends of LULCC in the study area at different time

3.1.1 Land use and land cover in 1988

Land use and land cover in 1988 year shows that grass land contains the largest area 3086.55 ha (30.8%) of the total area of the study area and the least area shared is wetland contains 884.79 ha (8.8%) of the total area (Table 4). Wetland contains nearly half of the area coverage of the lake and Settlement, which contain 1634.13 ha (16.3%) and 1585.8 ha (15.8%), respectively. Area share of wetland was nearly one-fourth of grass land and one-third of farmland constitutes 3089.55 ha (30.8%) and 2813.76 ha (28%) of the total area of the study area respectively. Land use and land cover in 1988 is the baseline for change detection in 2004 and 2018.

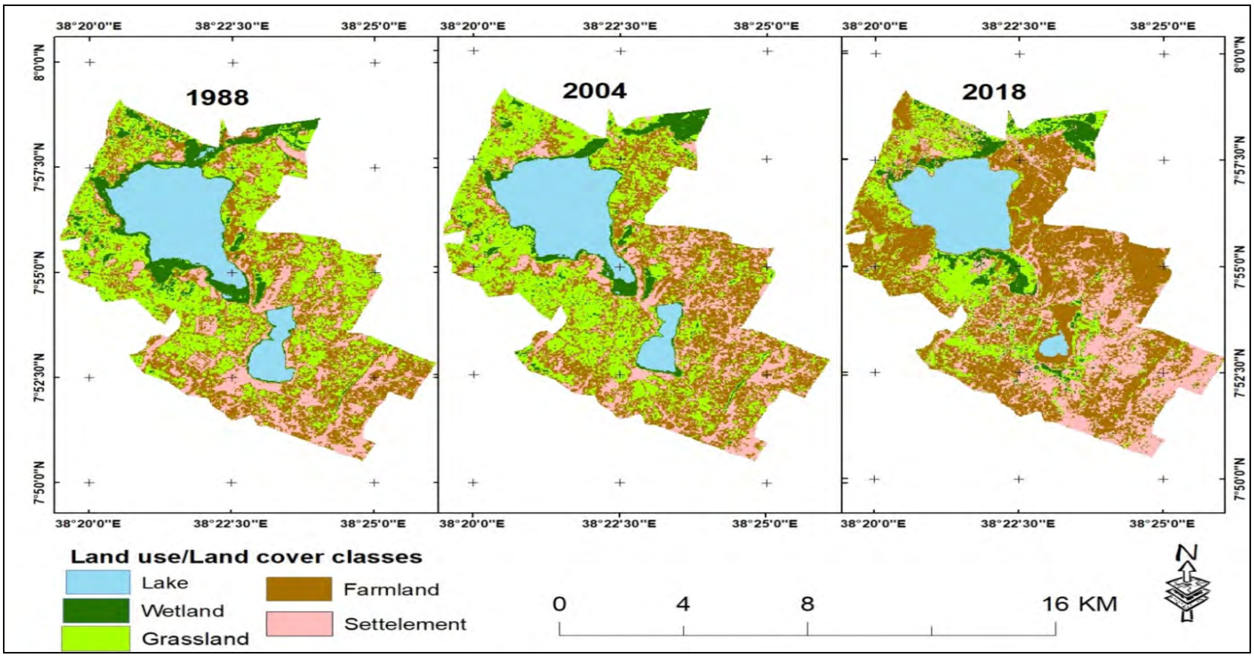

Fig. 1 LULCC change map of the study area.

Table 4 Land use and land cover and their area extent of 1988, 2004 and 2018.

LULC Class	1988		2004		2018		% of Change (1988-2018)
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area %	
Lake	1634.13	16.33	1517.13	15.16	1214.25	12.13	-25
Wetland	884.79	8.84	657.81	6.57	537.06	5.37	-40
Grassland	3086.55	30.85	3022.91	30.21	1619.55	16.18	-50
Farmland	2813.76	28.12	3135.96	31.34	4312	43.09	50
Settlement	1585.8	15.85	1671.22	16.70	2322.17	23.21	46
Total	10005.03	100	10005.03	100	10005.03	100	

3.1.2 LULCC between 1988 and 2004

After 16 years (2004), the change in the area coverage over this period was very slow (ranging from 0.5-3% of 1988) (Table 5). Farmland showed relatively highest increment nearly 322 ha (3%), while wetland showed the highest declining trend nearly 227 ha (2%) compared to area coverage in 1988. This is due to the conversion of wetland into agricultural land by human settlement observed increment trend nearly 1%. Similarly, Mintesnot et al. (2021) stated that wetland disturbance through cultivation and vegetation clearance alters wetlands functionality leading to their degradation. Furthermore, little change was recorded related to land use cover for the area coverage of lake and grassland, which is declined by 117 ha (1%) and 66.6 ha (0.5%), respectively due to sufficient area related to wetland presence**.**

Table 5 LULCC matrix and its area in ha between 1988 and 2004.

Class Name		Land Use 2018						
		Lake	Wetland	Grassland	Farmland	Settlement	Grand Total	Class Change
Land use 1988	Lake	1197.81	38.88	116.1	124.65	156.69	1634.13	436.32
	Wetland	15.03	257.49	53.46	323.28	235.53	884.79	627.3
	Grassland	0.18	75.09	1888.62	927.09	195.57	3086.55	1197.93
	Farmland	0	99.53	176.31	1506.97	1030.95	2813.76	1306.79
	Settlement	0	32.31	361.08	959.49	232.92	1585.8	1352.88
	Grand Total	1213.02	503.3	2595.57	3841.48	1851.66	10005.03	4453.13
	Class change	15.21	245.81	706.95	2334.51	1618.74	4921.22	

3.1.3 LULCC between 2004 and 2018

As shown in Table 6, the highest LULCC was observed between 2004 and 2018 in farmland increased by nearly 40%, while grassland decreased by nearly 50 percent in 2004. On the other hand, the area share of lake and wetland declined by nearly 20% of the area cover recorded in 2004, while settlement increased by nearly 40 percent of the area coverage of the settlement in 2004 (Table 5). The researcher has feared for the future if there is no touchable control measure for the rapid degradation of natural resources in the study area immediately responded.

Table 6 LULCC matrix and its area in ha between 2004 and 2018.

Class Name		Land Use 2004						
		Lake	Wetland	Grassland	Farmland	Settlement	Grand Total	Class change
Land Use 1988	Lake	1547.64	20.52	0.45	0.09	0.09	1568.79	21.25
	Wetland	7.92	299.43	22.59	134.19	43.38	507.51	208.08
	Grassland	20.34	118.53	1318.59	735.75	273.96	2467.17	1148.58
	Farmland	9.45	115.56	662.76	1740.42	1037.7	3565.89	1825.47
	Settlement	16.11	66.42	364.59	732.42	716.13	1895.67	1179.52
	Grand Total	1601.46	620.46	2368.98	3342.87	2071.26	10005.03	4382.9
	Class Change	53.42	321.03	1050.39	1602.45	1355.13	4382.42	

3.1.4 LULCC between 1988 and 2018

The highest incremental change was observed in farmland in nearly 1498 ha (50%), while the highest reduction was seen in grassland up to 1470 ha (50%) of the area coverage of farmland and grassland in 1988. On the other hand, the study revealed that the lake and wetland showed reduction trend from 1988 to 2018 up to 420 ha (25%) and 347.73 ha (40%) when compared to the land use and land cover change of lake and wetland in the year of 1988 while settlement increased to 736.37 ha (46%) (Table 7).

After 30 years between 1988-2018, all LULC types were changed, even if LULCC between 1988 and 2018, the remarkable changes were observed in the recent 14 years between 2004 and 2018. It is clearly understood from current investigation that rapid change of degradation in the lake, wetland and grasslands were observed in the recent few years between 2004 and 2018 year, while rapid expansion of farmland and settlement were observed in the recent 14 years (Table 6). This result was similar with the study of Afework et al. (2015) which reported that in the overall study period, wetlands showed continuous reduction while farmland showed a continuous increment. The researchers concluded that most activity resulting in wetland degradation was caused by human factors associated with over population. In accordance to the current finding, Regasa et al. (2021) concluded that the most significant factor adversely changing the natural status of wetland and its resources with unfavorable and adverse impacts on the environment and livelihood is the human factors.

The declination of the lake causes severe reduction in Tinishu Abaya wetland to recharge the ground water. This was due to population growth which forced the farmers to expand their lands in a greater extent for cultivation and residential purposes than before to sustain their lives and poor watershed management, and lack of awareness and knowledge about wetlands in communities were the underlying force for this sever degradation. The finding of EWNRA (2003) revealed that the major land use/cover changes were derived mainly from the dynamic nature of agriculture practice (the abandonment of croplands) on the one hand and population growth related to settlement expansion. He concluded human settlement and croplands showed increments while; the water body, forestland (woodland), and wetlands showed a reduction from 1973 to 2009. Reports of Leykun, (2003), and Kumsa (2015) also reported population growth as the major driving force of LULCC in southwestern Ethiopia.

Table 7 LULCC matrix and its area in ha between 1988 and 2018.

Class Name		Land use 2018						
		Lake	Wetland	Grassland	Farmland	Settlement	Grand Total	Class Change
Land use 2004	Lake	1205.91	119.07	76.23	94.23	21.69	1517.13	311.22
	Wetland	7.11	205.38	20.34	295.83	129.15	657.81	452.43
	Grassland	0	37.46	1810.76	897.67	377.02	3122.91	1312.15
	Farmland	0	204.57	206.28	1557.54	1167.57	3135.96	1578.42
	Settlement	0	20.88	348.57	988.65	213.12	1571.22	1358.1
	Grand Total	1213.02	587.36	2462.18	3833.92	1908.55	10005.03	5012.32
	Class Change	7.11	381.98	651.42	2276.38	1695.43	5012.32	

3.2 LULCC matrix between 1988-2004, 2004-2018 and 1988-2018

LULCC matrix from 1988-2004 shows Tinishu Abaya wetland was continuously changed and it was changed nearly 40% when compared to other LULC. The highest conversion (134.19 ha (26.4%)) of wetland was due to in farmland, followed by settlement share (43.38 ha (10%)) and the least conversion (7.92 ha (1.6%)) of wetland was shown in Lake. On the other hand, wetland conversion to grassland constitutes 22.59 ha (4%). Between 1988 and 2004, nearly 60% of the wetland remains unchanged to other LULC (Table 5).

The highest (68.8%) LULC occurred between 2004 and 2018, while 205.38 ha (31.2%) of wetland remain unchanged. As indicated in Table 5, between 2004 and 2018 the greatest conversion of wetland was observed in farmland (45%) expansion, whereas the conversion of wetland to the lake was the smallest (1%). Meanwhile, the wetland converted to settlement and grassland was 20% and 3%, respectively (Table 6). 71% of the wetland was converted to other land use/cover classes between 1988 and 2018. Wetland is highly converted to farmland (37%), followed by settlement (26.6%) and grassland (6%) and lake (1.8%) in the year between 1988 and 2018 (Table 7).

In terms of land cover remained unchanged (1988-2018), including 1197.81 ha, 257.49 ha, 1888.62 ha, 1506.97ha, and 232.92 ha were quantified for lake, wetland, grassland, farmland and settlement respectively (Table 9). The current investigation signifies LULCC matrix (Table 7) Wetland, lake and grassland showed losing trend while farmland showed gaining trend from other LULC. LULCC matrix from 1988 to 2018 showed that continuous conversion of Tinishu Abaya wetland to LULC spatially to farmland and followed by settlement expansion. This study is similar to Mengistu (2008) reported that wetland and forests have got decrement in the study years. Throughout the course of the study years, farmland took the greatest share of area, which was changed from wetland.

The discussion made with residents clarified, the majority of them agreed with as agricultural practices (cropping, settlement expansion due to rapid population growth, over grazing due to livestock increment, and lack of awareness about proper wetland utilization were the major drivers of Tinishu Abaya wetland degradation. Therefore, population pressure was observed as future threatening factor for wetland degradation and disappearance if appropriate rehabilitation measures were not come into action.

3.3 Rate of LULCC

The rate of change for each category is depicted in Table 8. During the period of 1988 to 2004, in sixteen years, wetlands, the lake, and grassland were declined by the rate of 226.98, 117, and 63.64 ha yr^{-1} respectively, while farmland and settlement areas were increased by the rate of 322.2 and 85.42 ha yr^{-1}, with a high declining rate of wetland, the lake and grassland and inclining rate of farmland. At the next stage (2004-2018), the direction of change is the same as the earlier one, but the rate of change was high for grassland decreased by the rate of 1403.36 and farmland increased by1176.04 ha yr^{-1}.

Finally, from 1988 to 2018, wetlands, grassland and lake declined at the rate of 347.73, 1470, and 419.88, ha yr^{-1} while, farmland and settlement were inclined at the rate of 1498.24 and 736.37 ha yr^{-1} respectively. The rate of change was at various scales in different classes. A similar finding was made by EWNRA (2003) reported that an increasing trend on agricultural land and built-up at the rate of 1727.57 and 289.86 ha yr^{-1}, respectively, and decreasing trend on forest land, wetland and grazing land at the rate of 952.36, 42.71 and 145.79 ha yr^{-1} respectively from 1986 to 2000 in Southern Ethiopia and Forum for Environment (2007) also reported increasing rate of agricultural land and built-up area by 3720 and 595 ha yr^{-1} respectively and decreasing rate of forest land and grazing land by 702 and 1239 ha yr^{-1} respectively from 1973 to 2004 in Nadda Asendabo Watershed in Southwestern Ethiopia.

3.4 Accuracy assessment of 1988, 2004, and 2018

The accuracy assessment was conducted for all maps. The producer accuracy, user accuracy, and kappa statistics were computed. The result of overall classification accuracy assessment indicates 84.82%, 87.02%, and 90% in the years of 1988, 2004, and 2018, respectively. The reasons for the errors may include the similarity of reflectance between LULC classes and the rapid LULC dynamic nature of the study area. Overall accuracy analysis obtained in the current findings was similar to the report of Mckee (2007), FOE (2007), and Wasswa et al. (2013) which were 88%, 86.1%, and 91% respectively.

Table 8 Rate of change in LULC classes from 1988-2018.

LULC Class	1988-2004		2004-208		1988-2018	
	Area in ha	Area %	Area in ha	Area %	Area in ha	Area %
Lake	-117	-1.17	-302.88	-3.03	-419.88	-4.2
Wetland	-226.98	-2.27	-120.75	-1.21	-347.73	-3.47
Grassland	-63.64	-0.64	-1403.36	-14.03	-1470	-14.66
Farmland	322.2	3.22	1176.04	11.75	1498.24	14.97
Settlement	85.42	0.85	650.95	6.50	736.37	7.36

The negative sine (-) in the table showed that the declining rate.

4 Conclusion

Wetlands contribute significant roles in providing ecosystem functions and producing a number of products and services that are socially and economically important to the local community. However, the current findings obtained from satellite imagery analysis revealed the prevalence of wetland degradation resulted from the rapid expansion of farmland and settlement during 1988-2018 because of increased human population. Area shares of the wetland, lakes and grasslands contributed to the continuous reduction of wetland over the specified study periods. Even if LULCC occurred, a remarkable change of wetland was observed during 2004-2018 (14 years).

Generally, based on LULC changes observed in the area between the specified year's results, one can suggest that the wetland under study is under risk unless corrective measures could be taken by the concerned bodies. Therefore, an urgent action is needed now, because the longer we wait, the more difficult it will be to bring the wetlands and their complex web of life back to their former splendor. Therefore the following suggestions are made based on this study result:

1. Wetlands should be restored, rehabilitated, and conserved.
2. The government must develop alternative forms of land use including developing its considerable potential as sites for recreational fishing, other water sports, bee keeping, and eco-tourism.
3. Prioritization and management plans of upstream-downstream user relations and developing an appropriate wetland management policy are recommended.

Abbreviations

DANO: District Agricultural and Natural Resource Office
CSA: Central Statistical Agency
FAO: Food and Agricultural Organization
GIS: Geographic Information System
SZAND: siltie zone agriculture and natural resource department

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